

## I. AMENDMENT

### **IN THE CLAIMS:**

Please amend the claims as follows:

1-2. (Cancelled)

3. (Currently Amended) A method for controlling processing elements in a multiprocessor architecture to provide improved throughput for Fast Fourier Transform / Inverse Fast Fourier Transform (FFT/IFFT) computations, the method comprising the steps of:

computing, on a multiprocessor architecture including "P" processing elements, each butterfly of the first " $\log_2 P$ " stages of an FFT/IFFT on either a single one of the processing elements or on each of the "P" processing elements simultaneously;

distributing the computations of the butterflies in all the subsequent stages of the FFT/IFFT among the "P" processing elements such that each chain of cascaded butterflies consisting of those butterflies that have inputs and outputs connected together ~~are~~is processed by the same processing element to thereby eliminate the need for inter-processor communication among the processing elements after the computation of the first " $\log_2 P$ " stages of the FFT/IFFT; wherein the distributing of the computation of the butterflies subsequent to the first " $\log_2 P$ " butterflies is achieved by assigning operand addresses of each set of butterfly operands to each processing element in such a manner that the butterfly is processed by the same processing element that computed the connected butterfly of the previous stage in the same chain of butterflies; and

wherein the desired assignment of operand addresses is achieved by deriving the address of the first operand in the operand pair corresponding to the " $i^{\text{th}}$ "

stage of the computation from the address of the corresponding operand in the previous stage by inserting a "0" in the  $(i+1)^{\text{th}}$  bit position of the address, while the address of the second operand is derived by inserting a "1" in the  $(i+1)^{\text{th}}$  bit position of the operand address.

4. (Currently Amended) A method for controlling processing elements in a multiprocessor architecture to provide improved throughput for Fast Fourier Transform / Inverse Fast Fourier Transform (FFT/IFFT) computations, the method comprising the steps of:

computing, on a multiprocessor architecture including "P" processing elements, each butterfly of the first  $\log_2 P$  stages of an FFT/IFFT on either a single one of the processing elements or on each of the "P" processing elements simultaneously;

distributing the computations of the butterflies in all the subsequent stages of the FFT/IFFT among the "P" processing elements such that each chain of cascaded butterflies consisting of those butterflies that have inputs and outputs connected together ~~are~~ is processed by the same processing element to thereby eliminate the need for inter-processor communication among the processing elements after the computation of the first  $\log_2 P$  stages of the FFT/IFFT; and

~~computing of twiddle~~ twiddle factors for the butterfly computations at each processing element by initializing a counter and then incrementing it by a value corresponding to the number of processing elements "P" and appending the result with a specified number of "0"s.

5. (Currently Amended) A system for controlling processing elements in a multiprocessor architecture including ~~P~~ "P" processing elements, comprising:

a means for computing each butterfly of the first " $\log_2 P$ " stages of a Fast Fourier Transform / Inverse Fast Fourier Transform (FFT/IFFT) on either a single processing element or on each of "P" processing elements simultaneously;

an addressing means for distributing the computation of the butterflies in all the subsequent stages of the FFT/IFFT among the "P" processing elements such that each chain of cascaded butterflies consisting of those butterflies that have inputs and outputs connected together, ~~are~~ is processed by the same processing element to thereby eliminate the need for inter-processor communication among the processing elements after the computation of the first " $\log_2 P$ " stages of the FFT/IFFT;

a means for counting; and

a means for computing twiddle factors for the butterfly computations at each processing ~~elements~~ element, the means for computing initializing the means for counting and then incrementing the means for counting by a value corresponding to the number of processing elements "P" and appending the result with a specified number of "0"s.

6. (Previously Presented) A system as claimed in claim 5 wherein the addressing means comprises addresses generation means for deriving the operand addresses of the butterflies subsequent to the first " $\log_2 P$ " butterflies in such a manner that the butterfly is processed by the same processing element that computed the connected butterfly of the previous stage in the same chain of butterflies.

7. (Original) A system as claimed in claim 6 wherein the address generation means is a computing mechanism for deriving the address of the first operand in the operand pair corresponding to the " $i^{\text{th}}$ " stage of the computation from the address of the corresponding operand in the previous stage by inserting a "0" in the " $(i+1)^{\text{th}}$ " bit position of the address, and deriving the address of the second operand by inserting a "1" in the " $(i+1)^{\text{th}}$ " bit position of the operand address.

8. (Previously Presented) A system as claimed in claim 5 further including a computing mechanism for address generation of twiddle factors for each butterfly on the corresponding processing element.

9-13. (Cancelled)

10. (Currently Amended) The method of claim 15 wherein the first " $\log_2 P$ "  ~~$\log_2 P$~~ -stages of the transform are calculated on all of the processors operating in parallel.

11. (Currently Amended) The method of claim 15 wherein the method is performed on two processors, and wherein the first two stages of a radix-2 ~~fast-Fast~~ Fourier transform-~~Transform~~ or ~~inverse-fast~~ Inverse Fast Fourier transform-~~Transform~~ are calculated as a single radix-4 stage, and wherein the subsequent stages of the transform are computed as radix-2 stages.

12. (Currently Amended) The method of claim 11 wherein each of the chains comprises a single loop that iterates  $N/2 * (\log_2(N/2)) / (\text{number of processors})$  times.

13. (Original) The method of claim 12 wherein each butterfly computational block includes a plurality of operands each having an associated address, and wherein calculating chains of butterfly computational blocks corresponding to the subsequent stages comprises assigning addresses to each of the operands so that each butterfly block in a chain is calculated in the same processor.

14. (Currently Amended) A method of performing a ~~fast-Fast~~ Fourier transform-~~Transform~~ or ~~inverse-fast~~ Inverse Fast Fourier transform-~~Transform~~ on an input signal, the method comprising:

storing samples of the input signal in a memory;

retrieving the samples from the memory and from these retrieved samples calculating the butterfly computational blocks for the first " $\log_2 P$ "  $\log_2 P$ -stages of the transform on a single processor or on a plurality of processors operating in parallel; and

eliminating the need for communication among and between the processors after the computation of the first " $\log_2 P$ " stages of the transform by calculating chains of butterfly computational blocks corresponding to the subsequent stages of the transform within each of the processors, each chain of butterfly computational blocks that is calculated in a respective processor having inputs and outputs coupled in series;

wherein the first  $\log_2 P$  " $\log_2 P$ " stages of the transform are calculated on all of the processors operating in parallel;

wherein the method is performed on two processors, and wherein the first two stages of a radix-2 ~~fast-Fast~~ Fourier ~~transform-Transform~~ or ~~inverse fast~~ ~~Inverse Fast~~ Fourier ~~transform-Transform~~ are calculated as a single radix-4 stage, and wherein the subsequent stages of the transform are computed as radix-2 stages;

wherein each of the chains comprises a single loop that iterates  $N/2^{*(\log_2(N/2)) / (\text{number of processors})}$  times;

wherein each butterfly computational block includes a plurality of operands each having an associated address, and wherein calculating chains of butterfly computational blocks corresponding to the subsequent stages comprises assigning addresses to each of the operands so that each butterfly block in a chain is calculated in the same processor; and

wherein each butterfly computational block includes a pair of operands, and wherein the operand addresses of these operands are assigned by deriving the address of the first operand in the operand pair corresponding to the " $i^{\text{th}}$ " stage of the calculation in the chain from the address of the corresponding operand in the previous stage by inserting a "0" in the " $(i+1)^{\text{th}}$ " bit position of the operand address, and deriving

the operand address of the second operand by inserting a "1" in the  $(i+1)^{\text{th}}$  bit position of the operand address.

15. (Currently Amended) A method of performing a ~~fast-Fast~~ Fourier ~~transform-Transform~~ or ~~inverse-fast-Inverse Fast~~ Fourier ~~transform-Transform~~ on an input signal, the method comprising:

storing samples of the input signal in a memory;

retrieving the samples from the memory and from these retrieved samples calculating the butterfly computational blocks for the first  ~~$\log_2 P$~~  " $\log_2 P$ " stages of the transform on a single processor or on a plurality of processors operating in parallel;

eliminating the need for communication among and between the processors after the computation of the first " $\log_2 P$ " stages of the transform by calculating chains of butterfly computational blocks corresponding to the subsequent stages of the transform within each of the processors, each chain of butterfly computational blocks ~~that is~~ calculated in a respective processor having inputs and outputs coupled in series; and

initializing a counter and then incrementing the counter by a value corresponding to the number of processors and appending the result with a specified number of "0"s to compute the twiddle factors for each butterfly computational block.

16-17. (Cancelled)

18. (Currently Amended) A processor system, comprising:

a memory operable to store samples of an input signal;

a plurality of processors coupled to the memory, the plurality of processors operable to receive the samples from the memory and to use the samples to execute the butterfly computational blocks for the first " $\log_2 P$ " stages of a ~~fast-Fast~~ Fourier ~~transform-Transform~~ or ~~inverse-fast-Inverse Fast~~ Fourier ~~transform-Transform~~

on either a single one of the processors or on a plurality of the processors operating in parallel; and

address circuitry coupled to the memory and processor and operable to distribute the computation of the butterfly computational blocks in all stages subsequent to the first ~~log<sub>2</sub>P~~ "log<sub>2</sub>P" stages among the plurality of processors such that each chain of cascaded butterfly computational blocks in the transform ~~are-is~~ coupled in series and ~~are-is~~ computed by the same processor to thereby eliminate the need for communication among and between the processors after the computation of the first "log<sub>2</sub>P" stages of the transform;

wherein the address circuitry is further operable to derive operand addresses for each of the butterfly blocks subsequent to the first "log<sub>2</sub>P" butterfly blocks so that each of the butterfly computational blocks is computed by the same processor that computed a butterfly computational block of the previous stage in the same chain of butterfly computational blocks; and

wherein each butterfly computational block includes a pair of operands, and wherein the address circuitry assigns operand addresses of these operands by deriving the address of the first operand in the operand pair corresponding to the "<sup>i</sup><sup>th</sup>" stage of the calculation in the chain from the address of the corresponding operand in the previous stage by inserting a "0" in the "<sup>(i+1)</sup><sup>th</sup>" bit position of the operand address, and deriving the operand address of the second operand by inserting a "1" in the "<sup>(i+1)</sup><sup>th</sup>" bit position of the operand address.

19. (Currently Amended) A processor system, comprising:

a memory operable to store samples of an input signal;

a plurality of processors coupled to the memory, the plurality of processors operable to receive the samples from the memory and to use the samples to execute the butterfly computational blocks for the first "log<sub>2</sub>P" stages of a ~~fast-Fast~~ Fast Fourier transform-Transform or ~~inverse fast-Inverse Fast~~ Fast Fourier transform-Transform

on either a single one of the processors or on a plurality of the processors operating in parallel;

address circuitry coupled to the memory and processor and operable to distribute the computation of the butterfly computational blocks in all stages subsequent to the first ~~log<sub>2</sub>P~~ "log<sub>2</sub>P" stages among the plurality of processors such that each chain of cascaded butterfly computational blocks in the transform ~~are-is~~ coupled in series and ~~are-is~~ computed by the same processor to thereby eliminate the need for communication among and between the processors after the computation of the first "log<sub>2</sub>P" stages of the transform;

wherein the address circuitry is further operable to derive operand addresses for each of the butterfly blocks subsequent to the first "log<sub>2</sub>P" butterfly blocks so that each of the butterfly computational blocks is computed by the same processor that computed a butterfly computational block of the previous stage in the same chain of butterfly computational blocks; and

wherein the processors further comprise a counter that is initialized and then incremented by a value corresponding to the number of processors, an output of the counter being appended with a specified number of "0"s to compute twiddle factors for each butterfly computational block.

20. (Previously Presented) The processor system of claim 19 wherein each of the processors comprises a digital signal processor.

21. (Currently Amended) An electronic system, comprising:  
a processor system, including,

a memory operable to store samples of an input signal;

a plurality of processors coupled to the memory, the plurality of processors operable to receive samples from the memory and to use the samples to execute the butterfly computational blocks for the first "log<sub>2</sub>P" stages of a ~~fast-Fast~~ Fast Fourier Transform or ~~inverse fast-Inverse Fast~~ Fast Fourier transform-Transform on either a



single one of the processors or on a plurality of the processors operating in parallel;  
and

address circuitry coupled to the memory and processor and operable to distribute the computation of the butterfly computational blocks in all stages subsequent to the first ~~log<sub>2</sub>P~~ "log<sub>2</sub>P" stages among the plurality of processors such that each chain of cascaded butterfly computational blocks in the transform ~~are~~ is coupled in series and ~~are~~ is computed by the same processor to thereby eliminate the need for communication among and between the processors after the computation of the first "log<sub>2</sub>P" stages of the transform;

wherein the address circuitry is further operable to derive operand addresses for each of the butterfly blocks subsequent to the first "log<sub>2</sub>P" butterfly blocks so that each of the butterfly computational blocks is computed by the same processor that computed a butterfly computational block of the previous stage in the same chain of butterfly computational blocks; and

wherein the processors further comprise a counter that is initialized and then incremented by a value corresponding to the number of processors, an output of the counter being appended with a specified number of "0"s to compute twiddle factors for each butterfly computational block.

22. (Previously Presented) The electronic system of claim 21 wherein the electronic system comprises a communications system.

23. (Previously Presented) The electronic system of claim 21 wherein each of the processors comprises a digital signal processor.